International Journal of Surgery 9 (2011) 324–328

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.theijs.com

Original Research

Multimodality laparoscopic liver resection for hepatic malignancy – From conventional total laparoscopic approach to robot-assisted laparoscopic approach

Eric C.H. Lai*, Chung Ngai Tang, George P.C. Yang, Michael K.W. Li

Department of Surgery, Pamela Youde Nethersole Eastern Hospital, 3 Lok Man Road, Chai Wan, Hong Kong SAR, China

ARTICLE INFO

Article history:
Received 4 October 2010
Received in revised form
14 January 2011
Accepted 3 February 2011
Available online 18 February 2011

Keywords:
Hepatocellular carcinoma
Colorectal liver metastases
Liver neoplasm
Laparoscopic liver resection
Robotic surgery

ABSTRACT

Introduction: Laparoscopic liver resection can either be total laparoscopic or hand-assisted laparoscopic approach. The recent introduction of robotic surgical systems has revolutionized the field of minimally invasive surgery. It was developed to overcome the disadvantages of conventional laparoscopic surgery. The role of robotic system in laparoscopic surgery was not well evaluated yet. The aim of this cohort study was to evaluate the outcome of multimodality approach of laparoscopic liver resection for hepatic malignancy

Methods: From January 1998 to August 2010, all patients with hepatic malignancy underwent laparoscopic liver resection were included. A prospectively collected data was analyzed retrospectively.

Results: During the study period, a total of 56 patients with hepatic malignancies (hepatocellular carcinoma, HCC, $n = 42$; colorectal liver metastases, CLM, $n = 14$) underwent laparoscopic liver resection in our surgical unit. The majority of cases were performed by hand-assisted laparoscopic approach, $n = 31$ (55.3%) and the remainder were with total laparoscopic approach, $n = 10$ (17.9%) and robot-assisted laparoscopic approach, $n = 15$ (26.8%). The median operation time was 150 min (range, 75–307 min). The median blood loss during surgery was 175 ml (range, 5–2000 ml). Two patients (3.6%) needed open conversion and one patient (1.8%) needed to be converted to hand-assisted laparoscopic approach. The morbidity rate was 14.3%. There was no procedure-related death. 89.3% of patients had R0 resection and 10.7% of patients had R1 resection. The median hospital stay was 6.5 days (range, 2–13 days).

The 1-year, 3-year, and 5-year disease-free survival rates for HCC were 85%, 47%, and 38%, respectively. The 1-year, 3-year, and 5-year overall survival rates for HCC were 96%, 67%, and 52%, respectively. The 1-year, and 3-year disease-free survival rates for CLM were 92% and 72%. The 1-year, and 3-year overall survival rates for CLM were 100% and 88%, respectively.

Conclusions: Multimodality approach of laparoscopic liver resection of hepatic malignancy was feasible, and safe in selected patients. It was associated with a low complications rate. The mid-term and long-term survival outcome was favorable also.

1. Introduction

The development of minimally invasive surgery over the last two decades has a great impact on the surgical practice. Laparoscopic liver resection also becomes possible with the availability of new instruments that allow a relatively bloodless liver transection. The advantages of laparoscopic liver resection are those of minimally invasive surgery, such as early recovery, shorter hospital stay, and better cosmetic outcome.[1] The post-operative course after laparoscopic liver resection may also be improved in patients with cirrhosis because the abdominal wall is preserved, kinetics of the diaphragm are improved, collateral venous drainage is better and there is less post-operative ascites. However, the role of laparoscopic liver resection for hepatic malignancy is still unclear because of the uncertainty of the long-term results, and the fear of compromising the oncological resection. Available long-term survival data about laparoscopic liver resection for hepatic malignancy in the literature are limited still.[2–8]

Traditionally, laparoscopic liver resection can either be total laparoscopic or hand-assisted laparoscopic approach.[1] Techniques of hand-assisted laparoscopic has been attempted to bridge the gap between open and conventional total laparoscopic approach. The recent introduction of robotic surgical systems has revolutionized the field of minimally invasive surgery.[9] It was developed to overcome the disadvantages of conventional laparoscopic surgery.

* Corresponding author. Tel.: +86 852 2595 7123; fax: +86 852 2515 3195.
E-mail address: ericlai@alumni.cuhk.edu.hk (E.C.H. Lai).

1743-9191/$ – see front matter © 2011 Surgical Associates Ltd. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijsu.2011.02.004

However, the role of robotic system in laparoscopic surgery was not well evaluated yet.

The aim of the present cohort study was to evaluate the clinical outcome of multimodality approach of laparoscopic liver resection for hepatic malignancy.

2. Materials and methods

A prospective data collection of laparoscopic liver resection was initiated in our surgical center in 1998. The study population was a consecutive series of patients with hepatic malignancy who underwent conventional total laparoscopic liver resection, hand-assisted laparoscopic liver resection or robot-assisted laparoscopic liver resection in a tertiary referral center from January 1998 to August 2010. Robotic surgery was started in May 2009 in our hospital. Our programme of robot-assisted laparoscopic liver resection was started in June 2009. During the study period, a total of 42 patients with hepatocellular carcinoma (HCC) and 14 patients with colorectal liver metastases (CLM) underwent laparoscopic liver resection in our surgical unit.

The choice of conventional total laparoscopic liver resection, hand-assisted laparoscopic liver resection or robot-assisted laparoscopic liver resection was determined by the surgeon's preference. With the introduction of robotic system, almost all those suitable tumors for laparoscopic resection were performed by robot-assisted approach.

All patients had a chest X-ray, ultrasonography (USG) of abdomen, contrast computed tomography (CT) scan of abdomen and/or positron emission tomography (PET) scan. Laboratory blood tests including hepatitis B surface antigen, antibodies to hepatitis C, serum alpha-fetoprotein (AFP), carcinoembryonic antigen (CEA), serum albumin, total bilirubin, aspartate aminotransferase, alanine aminotransferase and prothrombin time were obtained and the Pugh's modification of Child's criteria was determined. Further investigations were performed only when there was clinical suspicious of extrahepatic metastases. Radiologic studies were reviewed in a multidisciplinary case management meeting held weekly.

The selection criteria included normal liver or Child's A cirrhosis, tumor size less or equal to 5 cm, and tumor located at anterio-inferio-lateral segments (Couinaud segments 2, 3, 4b, 5, 6) for laparoscopic resection. Solitary exophytic tumor $>$ 5 cm accessible to the laparoscopic approach was considered also. All procedures were performed by consultant surgeons with expert in hepatobiliary and laparoscopic surgery after obtaining informed consent. After operation, all patients were followed up with serial AFP, or CEA assay, and USG or CT scan of the abdomen was performed every 3–6 months.

2.1. Operative procedure of laparoscopic liver resection

The patient was placed in Lloyd-Davis position. The chief surgeon operated between patient's legs with assistants on each side. Preoperative laparoscopic staging was performed first before liver resection. A sub-umbilical open technique was used to insert a 10 mm port, and pneumoperitoneum was established with carbon dioxide insufflation to a maximum pressure of 12 mmHg. Using a 30° laparoscope, the liver surface, porta hepatic and peritoneal surface were inspected. A second access port was inserted in the right upper quadrant at the mid-clavicular line under video guidance. The laparoscopic USG (7.5 MHz; Aloka, Wallingford, Connecticut) was inserted through this port and was placed in contact with the liver and the porta hepatis. Apart from the preoperative staging and assessment of liver functional reserve, the subsequent plane of transection could then be easily determined. The planned transection plane was marked on the liver surface by diathermy.

The conventional total laparoscopic liver resection was performed with a 10-mm camera port, one 12-mm operative port and two/three 5-mm operative ports. The da Vinci® S Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) was used for all robot-assisted procedures. A 12-mm camera port, 12-mm operative port, and three working 8-mm robotic ports were utilized. The trocar insertion sites depended on the location of the hepatic lesion. For hand-assisted laparoscopic liver resection, the position of Gelport (Applied Medical Resources Corp, Rancho Santa Margarita, California) was governed by the position of patient and the type of liver resection. A 7-cm long transverse incision (based on the palm size of the operating surgeon) was made at the right side of abdomen, slightly above the level of the umbilicus. The incision should not be directly over the pathology or too close to the laparoscope, otherwise the visual field and the range of movement would be very limited. One 12-mm operative port and two/three 5-mm operative ports were used. The surgical technique was as follows. The ligaments attaching the liver were divided, e.g. left triangular ligament for left lateral sectionectomy and right triangular ligament for right liver pathology. The falciform ligament was routinely transected with the aid of LigaSure (Valleylab, Boulder, Colorado)) and the stump was grasped for retraction. For selected patients with good liver functional reserve, Pringle maneuver was used to apply intermittent vascular control to reduce blood loss. To accomplish this, the a vascular lesser omentum was divided and a vascular sling was passed around the hepatoduodenal ligament. If vascular control was required, the tension could be tightened and retained as needed. After these preliminary steps and provided the central venous pressure was optimal ($<$5 cm H2O), parenchymal resection was carried out using a Harmonic Scalpel (UltraCision; Ethicon, Cincinnati, Ohio) and ultrasonic surgical aspirator (Sonopet UST2000; M&M Co Ltd, Tokyo, Japan). Minor vessels and bile ducts were controlled with bipolar scissors. Application of either a titanium clip or endostapler was used for the main vascular branches and bile ducts. At the completion of the parenchymal transection, the raw surface was inspected for any bile leak or oozing and such areas were plicated with 2/0 polypropylene. An argon beam coagulator was also used to achieve hemostasis from any oozing surface. During the use of argon beam coagulator, surgeons and anesthetists should be aware that there is a potential to develop a gas embolism and that adequate precautions should be taken to prevent this such as selecting a low flow setting on the argon beam coagulator and adequate venting of the abdomen through chimneys in laparoscopic ports to maintain safe pressures of between 8 and 12 mmHg. All specimens were retrieved inside a protective bag.

2.2. Statistical method

Prospectively collected data, including intraoperative parameters, post-operative complications, hospital mortality, and disease progress, were analyzed. Overall survival and disease-free survival were measured from the date of operation to the time of death and to the time when recurrent tumor was first diagnosed, respectively. Survival analysis was estimated by the Kaplan–Meier survival method.

3. Results

During the study period, a total of 56 patients with hepatic malignancies (HCC, $n = 42$; CLM, $n = 14$) underwent laparoscopic liver resection in our surgical unit. These 56 resections were carried out on 39 male and 17 female patients with median age of 60 years old (rang, 35-82). Three resections were carried for the indication of recurrent HCC. The demographic data and preoperative status of the 56 patients were shown in Table 1 and Table 2. The median preoperative AFP level was 9.1 (range, 1.7–112290) ng/mL. The median preoperative CEA level was 7.5 (range, 1–92.8) ng/mL. The median follow-up period was 16.9 months (range, 1–142.5 months).

3.1. Intraoperative results

Surgical procedures and operative details were shown in Tables 3 and 4. The majority of cases were performed by hand-assisted laparoscopic approach, $n = 31$ (55.3%) and the remainder were with total laparoscopic approach, $n = 10$ (17.9%) and robot-assisted laparoscopic approach, $n = 15$ (26.8%). The median operation time was 150 min (range, 75–307 min). Only 2 major hepatectomy (3.6%) was performed. The rest of hepatectomy was minor resection. The median blood loss during surgery was 175 ml (range, 5–2000 ml). Only 6 patients (10.7%) needed post-operative blood transfusion. Two procedures (3.6%) need to be converted to open approach and one procedure (1.8%) needed to be converted to hand-assisted laparoscopic approach. One patient in the conventional total laparoscopic group underwent left lateral sectionectomy for HCC needed open conversion because of injury to the branch of left hepatic vein, which resulted in moderate bleeding, and the patient underwent immediate hemostasis and liver resection. The other patient in conventional total laparoscopic

Table 1
Characteristics of the 42 patients with HCC.

Sex ratio (M:F)	31:11
Age [mean ± SD]	58.2 ± 10.4
Liver status	
Liver cirrhosis (n)	40
Non-cirrhotic liver (n)	2
Hepatitis status	
Hepatitis B carrier (n)	39
Hepatitis C carrier (n)	2
Recurrent HCC	3
Preoperative liver function of cirrhotic liver	
Pugh's modification of Child's grade A	40

Table 2
Characteristics of the 14 patients with CLM.

Sex ratio (M:F)	8:6
Age [mean ± SD]	68.2 ± 9.5
Liver status	
Liver cirrhosis (n)	0
Non-cirrhotic liver (n)	14
Synchronous diseases (n)	5
Metachronous diseases (n)	9
Primary cancer location (n)	
rectum	6 (42.8%)
sigmoid	2 (14.3%)
recto-sigmoid junction	2 (14.3%)
right colon	4 (28.6%)
Previous open surgery for primary cancer (n)	4
Previous laparoscopic surgery for primary cancer (n)	7

group underwent left lateral sectionectomy resection for HCC needed open conversion to release the pneumoperitoneum since he had intraoperative marginal oxygen saturation caused by lobar lung collapse and atelectasis. One patient in the robot-assisted laparoscopic group underwent non-anatomical wedge resection for HCC needed to convert to hand-assisted laparoscopic approach because of injury to the branch of right hepatic vein, which resulted in moderate bleeding, and the patient underwent immediate hemostasis and liver resection.

3.2. Postoperative results

Pathology and post-operative outcome were shown in Tables 3 and 4. 89.3% of patients had R0 resection and 10.7% of patients had R1 resection. The median hospital stay was 6.5 days (range, 2–13 days). There was no in-hospital death after operation. The morbidity rate was 14.3%. Postoperative complications consisted of post-operative hemorrhage ($n = 1$), acute pulmonary oedema ($n = 2$), bile leakage with intra-abdominal abscess ($n = 1$), and wound infection ($n = 4$). The patient with post-operative hemorrhage needed relaparotomy for hemostasis. None of the patients developed liver failure, or encephalopathy. One patient was found to have a port site incisional hernia during follow-up.

3.3. Survival and recurrence for HCC

Sixteen (41%) of the 39 patients who were diagnosed for the first time as having HCC, developed disease recurrence (isolated intra-hepatic recurrence, $n = 13$; intra-hepatic recurrence and distant metastases, $n = 2$; and distant metastases only, $n = 1$). For the 3 patients with laparoscopic liver resection for recurrent HCC, only one patient had intra-hepatic disease recurrence at 17 months after surgery. No patients developed tumor recurrence over the liver transection region. No port site or peritoneal metastases was observed in all the patients. The mean time interval of recurrence was 18.4 months. 76.5% of the recurrence occurred in the first two-year after surgery.

The 1-year, 3-year, and 5-year disease-free survival rates were 85%, 47%, and 38%, respectively. The 1-year, 3-year, and 5-year overall survival rates were 96%, 67%, and 52%, respectively.

3.4. Survival and recurrence for CLM

Two patients had extrahepatic metastases and one patient had both intra-hepatic and extrahepatic metastases. The mean interval of recurrence was 8 months time. No port site or peritoneal metastases was observed in all the patients.

The 1-year, and 3-year disease-free survival rates were 92% and 72%. The 1-year, and 3-year overall were 100% and 88%, respectively.

Table 3
Tumor characteristics and operative outcome for HCC.

Variables	Hand-assisted laparoscopic approach ($n = 23$)	Conventional total laparoscopic approach ($n = 10$)	Robot-assisted laparoscopic approach ($n = 9$)
Tumor size (cm) [mean ± SD]	2.9 ± 1.4	2.5 ± 0.9	2.5 ± 1.6
Location of tumor(n)			
Segment II	4	6	2
Segment III	4	4	3
Segment II, III	0	0	1
Segment IVb	1	0	0
Segment V	3	0	0
Segment VI	10	0	3
Segment V, VI	1	0	0
Hepatocellular carcinoma (HCC)	21	9	9
Combined hepatocellular-cholangiocarcinoma	2	1	0
Main tumor with satellite nodules	4	3	1
Type of liver resection			
Wedge resection	9	5	6
Segmentectomy	7	1	0
Left lateral sectionectomy	6	4	3
Right hepatectomy	1	0	0
Surgical margins			
R0 resection	20	10	9
R1 resection	3	0	0
Operating time (minutes) [mean ± SD]	152.8 ± 32.0	97.7 ± 27.4	198 ± 48.5
Median blood loss (ml) [median(range)]	150 (80–210)	80 (5–2000)	100 (20–1000)
Pringle maneuver used (n)	18	2	6
Time of vascular clamping (minutes) [mean ± SD]	29 ± 12.3	12.5 ± 0.7	25.5 ± 8.9
Convert to open approach	0	2	0
Convert to hand-assisted approach	\	0	1
Postoperative complication (n)			
Bleeding	0	1	0
Pulmonary oedema	1	1	0
Wound infection	3	1	0
Post-operative hospital stay (days) [mean ± SD]	7.1 ± 2.0	7.7 ± 3.6	6.0 ± 1.9

Table 4
Tumor characteristics and operative outcome for CLM.

Variables	Hand-assisted laparoscopic approach ($n = 7$)	Conventional total laparoscopic approach ($n = 1$)	Robot-assisted laparoscopic approach ($n = 6$)
Tumor size (cm) [mean ± SD]	3.2 ± 2.2	2	3.3 ± 1.6
Location of tumor(n)			
Segment II	2	0	2
Segment III	2	0	0
Segment II, III	1	0	0
Segment IVb	0	0	1
Segment V	0	0	1
Segment VI	1	0	1
Segment V, VI	0	1	1
Segment VI, VII	1	0	0
Type of liver resection			
Wedge resection	2	1	3
Segmentectomy	0	0	0
Left lateral sectionectomy	4	0	3
Right hepatectomy	1	0	0
One-stage surgery for primary cancer and CRM (n)	3	0	0
Surgical margins			
R0 resection	5	1	5
R1 resection	2	0	1
Operating time (minutes) [mean ± SD]	142.9 ± 53.6	75	190.2 ± 91.6
Median blood loss (ml) [median(range)]	100 (50–300)	500	75 (20-200)
Pringle maneuver used (n)	0	0	3
Time of vascular clamping (minutes) [mean ± SD]	0	\	46.7 ± 15.3
Convert to open approach	0	0	0
Convert to hand-assisted approach	\	0	0
Postoperative complication (n)			
Bile leak	0	0	1
Post-operative hospital stay (days) [mean ± SD]	8.4 ± 3.2	6	6.8 ± 2.8

4. Discussion

The first consensus meeting on laparoscopic liver surgery was held in Louisville, Kentucky, in November 2008, incorporating the opinions of the world's experts in laparoscopic and open liver surgery.[2] The organizing committee selected 45 recognized experts from around the world with the most extensive published experience in both laparoscopic and open liver surgery. They concluded that laparoscopic liver surgery is a safe and effective approach to the management of surgical liver disease in the hands of trained surgeons with experience in hepatobiliary and laparoscopic surgery. Currently acceptable indications for laparoscopic liver resection are patients with solitary lesions, 5 cm or less, located in liver segments 2 to 6. The laparoscopic approach to left lateral sectionectomy should be considered standard practice. Nguyen et al. reviewed a total of 127 published articles of original series on laparoscopic liver resection with 2804 reported minimally invasive liver resections.[3] Fifty percent were for malignant tumors, 45% were for benign lesions, 1.7% were for live donor hepatectomies, and the rest were indeterminate. The most common laparoscopic liver resection was a wedge resection or segmentectomy (45%), followed by anatomic left lateral sectionectomy (20%), right hepatectomy (9%), and left hepatectomy (7%). Conversion from laparoscopy to open laparotomy and from laparoscopy to hand-assisted approach occurred in 4.1% and 0.7% of reported cases, respectively. Overall mortality was 0.3%, and morbidity was 10.5%, with no intraoperative deaths reported. The results of our cohort were comparable with international results. However, there was one major limitation of our cohort series. There was only 2 major hepatectomy in our series. Hence, more experience in major laparoscopic liver resection has to be demonstrated in order to maintain accuracy comparing our own results to the existed literature data.

Laparoscopic liver resection of HCC has not gained wide acceptance before and was a subject of controversy among liver surgeons. Difficult learning curves, adequate resection margins, tumor seeding, metastases of the wounds, and the long-term outcome are the major concerns in laparoscopic surgery for HCC. No prospective, randomized controlled trials have been established to compare laparoscopic with open liver resections for HCC. Several studies, however, have retrospectively compared laparoscopic with open liver resection.[10–15] Many groups have shown decreased blood loss, less pain medication requirement, and shorter length of hospital stay with laparoscopic versus open liver resection. In comparative studies, there were no differences in margin-free resections and survival outcome between laparoscopic and open liver resection. In addition, no incidence of port site recurrence or tumor seeding has been reported. However, long-term outcome data of laparoscopic liver resection for HCC was limited still in the literature. The 5-year overall and disease-free survival rates after laparoscopic liver resection for HCC were 50%–81% and 24%–45.6%, respectively.[10–17] Our cohort study showed favorable survival outcome also. The 1-year, 3-year, and 5-year disease-free survival rates were 85%, 47%, and 38%, respectively. The 1-year, 3-year, and 5-year overall survival rates were 96%, 67%, and 52%, respectively.

Laparoscopic liver resection for CLM has same challenges as HCC. Survival outcome data of laparoscopic liver resection for CLM was even scarcer in the literature. Nguyen et al. reported a multi-institutional, international cohort study on laparoscopic liver resection for CLM in 109 patients.[18] The majority of patients underwent prior abdominal operations (95%). Minimally invasive approaches included totally laparoscopic (56%) and hand-assisted laparoscopic (41%). There were 4 conversions to open surgery (3.7%), all due to bleeding. Actuarial overall survivals at 1-, 3-, and 5-year for the entire series were 88%, 69%, and 50%, respectively. Disease-free survivals at 1-, 3-, and 5-year were 65%, 43%, and 43%, respectively. To date, no prospective randomized control trial has been performed to compare survival between laparoscopic and open hepatic resections. The only nonrandomized comparative study of laparoscopic and open hepatectomy for CLM was performed by Castaing et al.[19] They compared two groups (60 patients each) from two highly specialized liver surgery centers in France. First, the laparoscopic group had a greater R0 resection rate than the open group (87% vs. 72%). Second, the two groups had comparable overall survival, with 1-, 3-, and 5-year rates of 97%, 82%, and 64% in the laparoscopic group, and 97%, 70%, and 56% in the open group. Third, disease-free survival was comparable between the two groups with 1-, 3-, 5-year rates of 70%, 47%, and 35% in the laparoscopic group and 70%, 40%, and 27% in the open group. A limitation of this study is that the open hepatic resections were performed in a large volume hepatobiliary center, whereas the laparoscopic approach was performed by a single master minimally invasive surgery surgeon. It is unclear whether or not these results can be generalized or reproducible. Our cohort study showed favorable survival outcome also. The 1-year, and 3-year overall were 100% and 88%, respectively. The 1-year, and 3-year disease-free survival rates were 92% and 72%, respectively.

Traditionally, laparoscopic liver resection can be performed with total laparoscopic approach or hand-assisted laparoscopic approach. Techniques of hand-assisted laparoscopic has been

attempted to bridge the gap between open and conventional total laparoscopic approach. In our study, the choice of conventional total laparoscopic liver resection, hand-assisted laparoscopic liver resection or robot-assisted laparoscopic liver resection was determined by the surgeon's preference. Initially, hand-assisted approach was introduced first and then followed by conventional laparoscopic approach. With the introduction of robotic system, almost all those suitable tumors for laparoscopic resection were performed by robot-assisted approach. In our study, we tended to use hand-assisted approach for those patients with larger tumor size and more cirrhotic liver. During the whole study period, the number of complications and R0 resection rate were almost evenly distributed in the each quadrant of the study period. This phenomenon may be explained by that 1) we only selected suitable cases for laparoscopic operation; and 2) all the operations were performed by experienced laparoscopic and liver surgeons. Obviously, total laparoscopic procedure is superior to hand-assisted approach in terms of wound pain, and cosmetic outcome as hand-assisted laparoscopic liver resection usually required a 6–8 cm incision for the placement of the hand-port. Another possible disadvantage of hand-assisted laparoscopic approach includes possible obstruction of the visual field by the surgeon's hand during the operation. By making the appropriate incision and port sites, one can minimize the possible disadvantage of obstruction of the visual field by the surgeon's hand. This wide incision can also be used as a window for the delivery of liver specimens. The benefits of hand-assisted laparoscopic approach in hepatectomy are: (1) facilitation in manual retraction, which may be the best atraumatic tool; (2) feasibility in assessing margins of resection with the use of tactile sensation; (3) safety in parenchymal dissection laparoscopically; and (4) possibility of immediate hemostasis and prevents air embolism in case the hepatic vein is severed.

The recent introduction of robotic surgical systems has revolutionized the field of minimally invasive surgery. It was developed to overcome the disadvantages of conventional laparoscopic surgery. Well-known advantages of the robotic system such as improved vision via 3-dimensional view, magnification, tremor suppression, and the flexibility of the instruments have allowed precise operating techniques in a variety of procedures in general surgery. The main drawback of advanced robotic surgery is the associated cost. At the current stage of development, the benefits of robot-assisted surgery in liver surgery have not yet been defined. Only a few case reports or series reporting the technique of robotic-assisted laparoscopic liver resection were available in the literature.[20–23] Our results are too preliminary for a meaningful statistical analysis. Since all the liver resection in this study didn't involve biliary-enteric anastomosis and porta hilar dissection, these potential advantages of robotic system was not shown in this study. However, we noted that the surgeons sitting in the console were more comfortable during the operation and the dexterity of the instruments may shorten the learning curve of attaining the skills. Of course, all these potential advantages need larger scale of study to validate.

In conclusion, multimodality approach of laparoscopic liver resection of hepatic malignancies was feasible, and safe in selected patients. It is associated with a low complications rate. The survival outcome was favorable also. However, the procedure should be performed by surgical team expert in hepatobiliary and laparoscopic surgery in properly selected patients. These favorable findings of multimodality approach of laparoscopic resection for hepatic malignancies need further investigation in larger scale of comparative studies. It is still too early to conclude which technique of laparoscopic liver resection is better.

Conflict of interest

None.

Funding

This study is not supported by any grant or sponsorships.

Ethical approval

None.

Author contribution

Eric C.H. Lai have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Chung Ngai Tang, George P.C. Yang, Michael K.W. Li have made substantial contributions to all of the following: (1) the conception and design of the study, (2) revising it critically for important intellectual content, (3) final approval of the version to be submitted.

References

1. Nguyen KT. Geller DA. Laparoscopic liver resection—current update. *Surg Clin North Am* 2010;**90**:749–60.
2. Buell JF, Cherqui D, Geller DA, O'Rourke N, Iannitti D, Dagher I, et al. World consensus Conference on laparoscopic Surgery.The international position on laparoscopic liver surgery: the Louisville Statement, 2008. *Ann Surg* 2009;**250**:825–30.
3. Nguyen KT, Gamblin TC, Geller DA. World review of laparoscopic liver resection-2,804 patients. *Ann Surg* 2009;**250**:831–41.
4. Lai EC, Lau WY. The continuing challenge of hepatic cancer in Asia. *Surgeon* 2005;**3**:210–5.
5. Lau WY, Lai EC. Hepatocellular carcinoma: current management and recent advances. *Hepatobiliary Pancreat Dis Int* 2008;**7**:237–57.
6. Lau WY, Lai EC. Hepatic resection for colorectal liver metastases. *Singapore Med J* 2007;**48**:635–9.
7. Tang CN, Li MK. Laparoscopic-assisted liver resection. *J Hepatobiliary Pancreat Surg* 2002;**9**:105–10.
8. Tang CN, Tsui KK, Ha JP, Yang GP, Li MK. A single-centre experience of 40 laparoscopic liver resections. *Hong Kong Med J* 2006;**12**:419–25.
9. Idrees K. Bartlett DL.Robotic liver surgery. *Surg Clin North Am* 2010;**90**:761–74.
10. Lai EC, Tang CN, Ha JP, Li MK. Laparoscopic liver resection for hepatocellular carcinoma: ten-year experience in a single center. *Arch Surg* 2009;**144**:143–7.
11. Belli G, Limongelli P, Fantini C, D'Agostino A, Cioffi L, Belli A, et al. Laparoscopic and open treatment of hepatocellular carcinoma in patients with cirrhosis. *Br J Surg* 2009;**96**:1041–8.
12. Endo Y, Ohta M, Sasaki A, Kai S, Eguchi H, Iwaki K, et al. A comparative study of the long-term outcomes after laparoscopy-assisted and open left lateral hepatectomy for hepatocellular carcinoma. *Surg Laparosc Endosc Percutan Tech* 2009;**19**:e171–4.
13. Sarpel U, Hefti MM, Wisnievsky JP, Roayaie S, Schwartz ME, Labow DM. Outcome for patients treated with laparoscopic versus open resection of hepatocellular carcinoma. *Case-matched Analysis.Ann Surg Oncol* 2009;**16**:1572–7.
14. Aldrighetti L, Guzzetti E, Pulitanò C, Cipriani F, Catena M, Paganelli M, et al. Case-matched analysis of totally laparoscopic versus open liver resection for HCC: short and middle term results. *J Surg Oncol* 2010;**102**:82–6.
15. Tranchart H, Di Giuro G, Lainas P, Roudie J, Agostini H, Franco D, et al. Laparoscopic resection for hepatocellular carcinoma: a matched-pair comparative study. *Surg Endosc* 2010;**24**:1170–6.
16. Lai EC, Tang CN, Yang GP, Li MK. Minimally invasive surgical treatment of hepatocellular carcinoma: long-term outcome. *World J Surg* 2009;**33**:2150–4.
17. Dagher I, Belli G, Fantini C, Laurent A, Tayar C, Lainas P, et al. Laparoscopic hepatectomy for hepatocellular carcinoma: a European experience. *J Am Coll Surg* 2010 Jul;**211**(1):16–23.
18. Nguyen KT, Laurent A, Dagher I, Geller DA, Steel J, Thomas MT, et al. Minimally invasive liver resection for metastatic colorectal cancer: a multi-institutional, international report of safety, feasibility, and early outcomes. *Ann Surg* 2009;**250**:842–8.
19. Castaing D, Vibert E, Ricca L, Azoulay D, Adam R, Gayet B. Oncologic results of laparoscopic versus open hepatectomy for colorectal liver metastases in two specialized centers. *Ann Surg* 2009;**250**:849–55.
20. Patriti A, Ceccarelli G, Bartoli A, Spaziani A, Lapalorcia LM, Casciola L. Laparoscopic and robot-assisted one-stage resection of colorectal cancer with synchronous liver metastases: a pilot study. *J Hepatobiliary Pancreat Surg* 2009;**16**:450–7.
21. Choi SB, Park JS, Kim JK, Hyung WJ, Kim KS, Yoon DS, et al. Early experiences of robotic-assisted laparoscopic liver resection. *Yonsei Med J* 2008;**49**:632–8.
22. Giulianotti PC, Giacomoni A, Coratti A, Addeo P, Bianco FM. Minimally invasive sequential treatment of synchronous colorectal liver metastases by laparoscopic colectomy and robotic right hepatectomy. *Int J Colorectal Dis* 2010;**25**:1507–11.
23. Giulianotti PC, Coratti A, Sbrana F, Addeo P, Bianco FM, Buchs NC, Annechiarico M, Benedetti E. Robotic liver surgery: Results for 70 resections. *Surgery* 2011;**149**:29–39.